

# **Validity of a self-administered questionnaire version of the Transition Dyspnea Index in patients with COPD**

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## **Abstract**

The transition dyspnea index (TDI) is among the most widely used instruments in COPD patients to measure changes in dyspnea over time. In its original version it is used as guideline for a structured interview to assess the impact of daily activities on dyspnea in the three subdomains functional impairment, magnitude of task, and magnitude of effort. However, the TDI is sometimes used as a self-administered paper-and-pencil questionnaire. The validity of this questionnaire format has not been tested, which was the aim of the present study.

We tested 190 patients with COPD at start and end of a 3-week inpatient pulmonary rehabilitation program (PR). Dyspnea was assessed with the modified Medical Research Council Scale (mMRC), a questionnaire version of the TDI, and an interview version of the TDI.

Group means for the TDI questionnaire and interview version were widely comparable for the TDI summary score and the three TDI subdomains. The scores of both TDI versions were strongly correlated and showed comparable, but only weak, correlations with changes during PR in spirometric lung function and mMRC. Improvement in dyspnea after PR was observed in 89% of patients when using the summary score of the questionnaire TDI, but only in 34% of patients when using the mMRC.

The results suggest that a self-administered questionnaire format of the TDI is an adequate instrument for assessing changes in activity-related dyspnea during PR in patients with COPD. The responsiveness of this instrument to effects of PR appears greater than the responsiveness of the mMRC.

# Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a prevalent and debilitating respiratory disease, characterized by persistent and usually progressive airflow limitation [1, 2]. It is the third leading cause of mortality worldwide and associated with significant individual and socioeconomic burden [1, 3, 4]. Dyspnea is the highly aversive cardinal symptom of COPD and causing significant reductions in patients activity levels and quality of life [1, 5, 6]. In fact, dyspnea is an important predictor of mortality in COPD with greater predictive value than spirometric lung function measures [7, 8]. Consequently, reducing dyspnea is among the most important clinical outcomes in COPD [1, 9, 10], requiring its routine monitoring, for example to evaluate treatment responses [11–13].

In this regard, several instruments are available allowing patients to report the impact of daily activities on their dyspnea [14]. Specifically, the (modified) Medical Research Council scale (mMRC) [15, 16] and the Transition Dyspnea Index (TDI) [17] are among the most widely used instruments in clinical trials to assess changes in dyspnea with therapy [18, 19]. Using the mMRC scale, the patient is asked to choose one of five grades that most closely matches daily activities (eg, walking) that provoke dyspnea [16]. Potential limitations of the unidimensional mMRC are its exclusive dependence on individual activity levels and its limited response format. In order to overcome these limitations, Mahler and colleagues developed the multidimensional TDI (together with its companion Baseline Dyspnea Index, BDI) to measure changes in dyspnea over time [17]. In its original version it is used as guideline for a structured interview to assess the impact of daily activities on dyspnea in the three subdomains of functional impairment, magnitude of task, and magnitude of effort. These dimensions are further condensed into a summary score [17]. The psychometric properties of the TDI have been established [20–22] and it has been used widely in clinical trials evaluating various treatments in patients with COPD including pharmacotherapy [23, 24] and pulmonary rehabilitation (PR) [25–28] with greater responsiveness to change than the MRC [29, 30]. In addition, a self-administered computerized version of the TDI has been developed and validated, which showed comparable responsiveness to changes in dyspnea than the interviewer-administered version [30, 31]. However, in clinical praxis the TDI is sometimes used as a self-administered paper-and-pencil questionnaire, which might represent a more economical alternative since it is independent of both

interviewer and computer skills of respondents. To our knowledge, the validity of this TDI questionnaire format has yet not been tested.

Therefore, the primary aim of the present study was to test the validity of a self-administered paper-and-pencil format of the TDI for assessing changes in dyspnea in a large sample of patients with COPD undergoing a multidisciplinary PR program. Specifically, we tested the hypotheses that the TDI questionnaire version would (1) show comparable responsiveness than the TDI interview version and (2) demonstrate greater responsiveness to PR than the mMRC.

## **Material and methods**

### ***Study design***

This is a prospective, observational study in patients with COPD undergoing a multidisciplinary PR program. The primary outcome variables were dyspnea ratings using a TDI questionnaire and interview version, while secondary outcome variables included changes in mMRC dyspnea ratings and spirometric lung function measures.

### ***Participants***

We studied 190 consecutive patients with COPD who completed an established and standardized 3-week multidisciplinary inpatient PR at the Centre for Rehabilitation, Pneumology and Orthopedics (Clinic Bad Reichenhall, Germany) between May and November 2014. Anamnestic interviews and diagnostic classification were performed by pulmonary physicians according to GOLD criteria [1]. Spirometry and bodyplethysmography was performed by specialized and trained diagnostic staff using a Masterlab 4.0 (Jaeger-Thoennies CareFusion, Hoechberg, Germany) according to ATS/ERS criteria [32]. Reference normal values for the forced expiratory volume in the first second (FEV<sub>1</sub>%pred) and the vital capacity (VC%pred) were taken from Quanjer et al. [33]. Inclusion criteria were (1) diagnosis of COPD according to GOLD criteria [1], (2) stable clinical condition, and (3) the ability to read and understand German. The

following sociodemographic and clinical variables were collected for this study: age, gender, FEV<sub>1</sub>, VC, dyspnea (TDI, mMRC), COPD-severity (based on GOLD criteria [1]), body mass index (BMI), exacerbations in preceding 12 months, 6-min walking distance (6MWD), chronic oxygen use, and smoking status. The study was approved by the local ethics committee (Bayerische Landesärztekammer, No. 12107) and all patients provided written informed consent.

### ***mMRC scale***

The patients read the German language version of the 5-point mMRC scale [16], which was presented on a piece of paper, and circled the grade (0 to 4) that most closely matches the daily activities that provoke dyspnea. Higher scores represent more dyspnea.

### ***Questionnaire-TDI***

The patients read the German language version of the TDI [17], which was presented on a piece of paper. Compared to the interviewer administered version, the statements were slightly re-phrased into a first-person form (eg, 'I was formerly working and had to stop working [...] instead of 'Formerly working and has had to stop working [...]'). Patients were instructed to read these statements on changes in functional impairment attributed to dyspnea, magnitude of the task that produces dyspnea, and magnitude of effort exerted to produce dyspnea and to relate these changes to the time directly before PR. They circled the statement that most closely matched their perceived changes in dyspnea. Resultant scores ranged for each of the three dimensions from +3 (major improvement) to -3 (major deterioration), with an additional, non-scored response option ('Further impairment for reasons other than shortness of breath').

### ***Interview-TDI***

The patients were questioned individually by a trained interviewer (study assistant). The interviewer rated the change in dyspnea in the same three dimensions as the questionnaire TDI, again in relation to the time directly before PR and using the same response scores.

## ***Procedure***

At the start of PR, patients provided informed written consent, underwent anamnestic and diagnostic examinations, performed spirometric lung function testing and filled out the mMRC. Thereafter, patients completed the routine 3-week multidisciplinary inpatient PR programme. At the end of PR, all measurements were repeated. In addition, the pre-post PR change in activity-related dyspnea was assessed with the two versions of the TDI. In analogy to the validation studies of the self-administered computerized version of the TDI by Mahler et al. [30, 31], the questionnaire-TDI was always completed first, followed by the interview-TDI. This order avoided potentially biasing influences of the interview on the subsequent self-administered version, which have been reported earlier [31].

## ***Statistical Analysis***

Outcome measures are presented as mean ( $\pm$  SD). The scores for the three dimensions of the questionnaire-TDI and interview-TDI as well as the respective summary scores (range: -9 to +9) were calculated. Following the analyses strategy of Mahler et al. [30, 31], paired t-tests were used to compare the questionnaire and interview versions. Pearson correlation coefficients (two-tailed) were used as a measure of the goodness of fit, completed by calculating intraclass correlation coefficients (ICC) to indicate the absolute agreement between both TDI version. A Bland-Altman plot was used to examine the relationship between the difference of the summary scores of the questionnaire-TDI and interview-TDI and the mean score of both TDI versions. In addition, the associations between the two TDI summary scores and changes in lung function ( $\Delta$ FEV<sub>1</sub>%pred,  $\Delta$ VC%pred) and dyspnea ( $\Delta$ mMRC) from start to end of pulmonary rehabilitation were analysed using Pearson correlation coefficients (two-tailed). Data were analyzed using SPSS 23 software (SPSS Inc., Chicago, IL) using a statistical significance threshold of  $\alpha < .05$ .

## ***Results***

Baseline characteristics of the 190 patients (61 female patients, 129 male patients) are presented in Table 1. The majority of patients had moderate to severe levels of COPD according to GOLD criteria [1]. As a group,

the patients demonstrated moderate dyspnea during activities ( $mMRC = 2.60 \pm 1.15$ ) and moderate to severe impairment in lung function ( $FEV_1\%pred = 51.27 \pm 14.79$ ).

### Table 1 about here ###

Mean ( $\pm$  SD) values for the questionnaire-TDI and interview-TDI as well as their correlations are presented in table 2. Inspection of the group means for both TDI versions reveals that these were widely comparable for the summary score (4.3 vs. 4.5) (figure 1) and for the subdomains functional impairment (1.2 vs. 1.4), magnitude of task (1.8 vs. 1.8), and magnitude of effort (1.3 vs. 1.3). However, t-tests indicated that the small difference of 0.2 units between both TDI versions was statistically significant for the summary score ( $t(189) = 2.90$ ,  $p < .05$ ) and the subdomain functional impairment ( $t(189) = 2.49$ ,  $p < .01$ ) with slightly lower scores for the questionnaire-TDI. The Bland-Altman plot in Figure 2 shows that the majority of patients showed no difference in the summary scores between the questionnaire-TDI and interview-TDI.

### Table 2 and figures 1, 2 about here ###

The correlations between the TDI versions were very high and statistically significant for all scores ( $p$ 's  $< .001$ ) with a range from  $r = 0.73$  (functional impairment) to  $r = 0.98$  (magnitude of effort). Similarly, ICCs between the TDI versions were very high ranging from  $ICC = 0.84$  (functional impairment) to  $ICC = 0.99$  (magnitude of effort) (table 2). Comparable correlations between the summary scores of both TDI versions and changes in lung function ( $\Delta FEV_1\%pred$ ,  $\Delta VC\%pred$ ) and dyspnea ( $\Delta mMRC$ ) during PR were observed (table 3). Although statistically significant, these correlations were only of weak magnitude ( $r$ 's = 0.17 to - 0.24).

### Table 3 about here ###

Notably, the majority of patients ( $N = 169$ , 89%) experienced an improvement in dyspnea after PR as measured by the summary score of the questionnaire-TDI, while only a minority of 12 patients (6%) reported

no change. In contrast, only a minority of patients ( $N = 64$ , 34%) experienced an improvement in dyspnea after PR when measured with the mMRC, while the majority of patients ( $N = 108$ , 57%) reported no change. For these same 108 patients, the mean summary score of their questionnaire-TDI was  $3.7 (\pm 3.4)$  (for the interview-TDI:  $4.0 \pm 3.1$ ), which is clearly above the minimal clinically important difference for the TDI of +1 unit [20].

## Discussion

The present study examined the validity of a self-administered paper-and-pencil format of the TDI for assessing changes in activity-related dyspnea in patients with COPD undergoing a multidisciplinary PR program. Specifically, we compared a TDI questionnaire version with a TDI interview version and further compared the questionnaire-TDI with the mMRC regarding the responsiveness to PR. The major findings of this study in 190 patients with COPD are as follows: (1) the questionnaire-TDI provides comparable estimates for changes in dyspnea during PR than the interview-TDI; (2) both TDI versions show comparable, but weak associations with changes in lung function; and (3) the responsiveness of the questionnaire-TDI to changes in dyspnea during PR is greater than that of the mMRC. Together, these results suggest that a self-administered paper-and-pencil format of the TDI might be an adequate instrument for assessing changes in dyspnea during PR in patients with COPD. This questionnaire format might be a more economical alternative to the interview format in cases where no interviewers are available, for example in postal surveys, and it is independent of computers and computer skills of respondents.

The present result converge with previous findings by Mahler and colleagues who compared a self-administered computerized version of the TDI with an interview version [30, 31]. As in the present study, they merely observed a minimally lower mean value for the summary score of the self-administered computerized TDI version when compared to the interview version (1.4 vs. 1.8) [30]. Similarly, they reported high correlations between both TDI versions, which resemble those obtained in the present study [30, 31]. Notably, the correlations ( $r = 0.94$ ) between the TDI summary scores of the self-administered and interview versions are identical in the current study and in Mahler et al. [31].



In the present study, we observed comparable correlations between the summary scores of both TDI versions and changes in lung function during PR that, although statistically significant, were of rather weak size. This corresponds with several previous studies, which similarly reported only modest associations between dyspnea ratings and lung function measures in patients with COPD [17, 30, 31, 34–36]. Together, these findings emphasize that dyspnea measures represent a different construct than the results of lung function testing and underscore the pivotal importance of routine assessments of dyspnea in patients [11–13].

In this regard, differences exist in the responsiveness of different instruments used for the assessment of dyspnea [14, 29, 37]. For example, the present study revealed only weak correlations between the changes in the mMRC score during PR and the summary scores of both questionnaire-TDI and interview-TDI. This is in line with previous studies which also observed only modest correlations between TDI scores and changes in MRC scores after PR or pharmacotherapy, respectively [29, 30]. Also in other patient-reported domains such as quality of life, only weak correlations between different instruments for the measurement of changes (eg, prospective vs. retrospective instruments) have been reported [38, 39]. Importantly, the choice of measurement instrument significantly impacts the evaluation of treatment success. In the present study, the majority of patients (89%) reported an improvement in dyspnea after PR when using the questionnaire-TDI, whereas only a minority of patients (34%) reported an improvement in dyspnea when using the mMRC. In fact, the majority of patients (57%) reported no change in dyspnea based on their mMRC ratings, although the mean summary TDI scores of these very same patients were clearly above the minimal clinically important difference for this instrument, thus indicating a relevant improvement in dyspnea during PR. A similar disagreement between TDI scores and MRC scores after PR and pharmacotherapy was reported previously [29, 30]. For example, in the study by Mahler and colleagues [30] 55% of the patients reported no change in dyspnea using the MRC, whereas the mean TDI scores of the same patients indicated an improvement in dyspnea by reaching the minimal clinically important difference. Together, these findings underscore the limited responsiveness of the (m)MRC for measuring changes in dyspnea and for evaluating treatment response [29, 30, 35].

## **Conclusion**

The present findings suggest that a self-administered questionnaire format of the TDI is an adequate instrument for assessing changes in dyspnea during PR in patients with COPD. It provides comparable estimates for changes in activity-related dyspnea than the interviewer format with comparable, but weak associations with lung function measures. The responsiveness of this instrument to effects of PR appears greater than the responsiveness of the mMRC.

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## **Declaration of Interest**

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**Table 1** Mean (SD) baseline characteristics of participants

Characteristics	Data
Age (yr)	58 (8)
Sex (female/male), No.	61/129
FEV <sub>1</sub> (L)	1.59 (0.57)
FEV <sub>1</sub> (% predicted)	51 (15)
VC (L)	3.31 (0.91)
VC (% predicted)	83 (15)
FEV <sub>1</sub> /VC (%)	48 (11)
Dyspnea (mMRC)	2.60 (1.15)
BMI (kg * m <sup>-2</sup> )	27.3 (6.6)
Exacerbations in preceding 12 months, No.	2.3 (1.1)
6MWD (m)	436 (110)
Chronic oxygen use, No.	18
Smoking status, No.	
Current smoker	73
Former smoker	108
Never smoker	9
COPD-severity based on airflow limitation according to GOLD (No.)	
II	88
III	73
IV	29
COPD-severity based on combined assessment according to GOLD (No.)	
A	6
B	53
C	4
D	127

*Abbreviations:* 6MWD = 6-minute walk distance; BMI = body mass index; FEV<sub>1</sub> = forced expiratory volume in first second; VC = vital capacity; mMRC = modified Medical Research Council Scale

**Table 2** Means (SD) and correlations of questionnaire-TDI and interview-TDI

	Questionnaire-TDI	Interview-TDI	Correlations ‡	Correlations Mahler et al. [30, 31]
Functional impairment <sup>#</sup>	1.2 (1.3)	1.4 (1.1)	0.74*** (0.84)	0.72***
Magnitude of task	1.8 (1.1)	1.8 (1.1)	0.96*** (0.98)	0.80***
Magnitude of effort	1.3 (1.2)	1.3 (1.1)	0.98*** (0.99)	0.78***
TDI summary score <sup>§</sup>	4.3 (3.2)	4.5 (3.0)	0.94*** (0.97)	0.94***

<sup>#</sup>  $p < 0.05$  and <sup>§</sup>  $p < 0.01$  for the comparison between questionnaire-TDI and interview-TDI

\*\*\*  $p < 0.001$

‡ intraclass correlation coefficients are presented in parentheses

Note: The right column presents comparable correlations between an interviewer-administered and a self-administered computerized version of the TDI as obtained by Mahler et al. [30, 31]



**Table 3** Correlations of TDI summary scores and changes in lung function and dyspnea from start to end of pulmonary rehabilitation

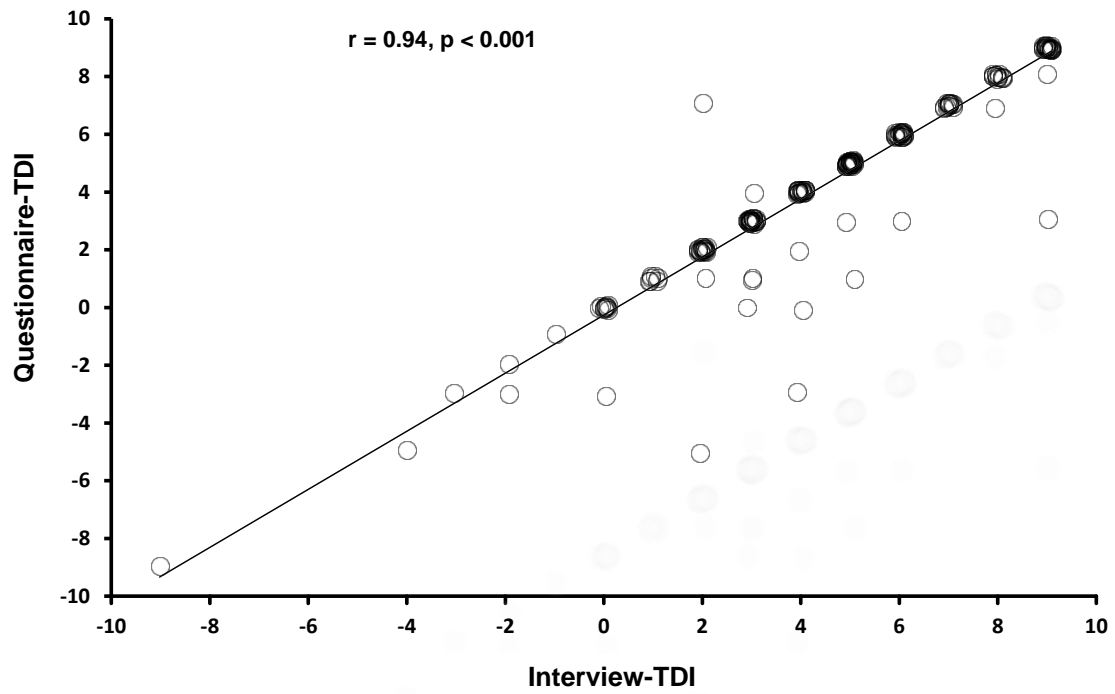
	Questionnaire-TDI	Interview-TDI
$\Delta\text{FEV}_1$ (% predicted)	0.17*	0.21**
$\Delta\text{VC}$ (% predicted)	0.17*	0.20**
$\Delta\text{Dyspnea}$ (mMRC)	-0.22**	-0.24**

\*  $p < 0.05$ , \*\*  $p < 0.01$

*Abbreviations:*  $\text{FEV}_1$  = forced expiratory volume in first second; VC = vital capacity; mMRC = modified Medical Research Council Scale

**Figure 1**

Summary scores for questionnaire-TDI and interview-TDI



**Figure 2**

Bland-Altman plot showing the difference between the questionnaire-TDI and interview-TDI summary scores against the mean of the questionnaire-TDI and interview-TDI summary scores. Overall, the majority of patients showed no difference in dyspnea estimates between the questionnaire and interview TDI version. The range of summary scores for the TDI is -9 (deterioration) to +9 (improvement). Solid line: mean value; dashed line: mean  $\pm$  1.96 SD of the scores.

